

Section 110(l) Technical Support Document

Introduction for Photochemical Modeling for Ozone and PM_{2.5} Assessment

IDEM's Office of Air Quality conducted photochemical modeling to determine whether the discontinuation of the vehicle inspection and maintenance program in Clark and Floyd counties would adversely affect the area's ability to attain or maintain compliance with applicable National Ambient Air Quality Standards. The discontinuation of the vehicle inspection and maintenance program does result in the loss of NO_x and VOC emission reductions, and thus could affect ozone and fine particle concentrations. This potential increase in emissions was determined using local travel demand model data and emission factors deriving from MOBILE6. The increased emissions were added to the existing emission profiles for Clark and Floyd counties and were modeled and compared to the previous modeling results that included the vehicle inspection and maintenance program in Clark and Floyd counties. Any difference between the two model runs represents the impact on future year design values for ozone or PM_{2.5} monitors located in Clark and Floyd counties.

Emissions Estimation and Photochemical Modeling Methodologies

IDEM is a member of the Midwest Regional Planning Organization (MRPO), which uses photochemical modeling to determine emission control strategies for attainment State Implementation Plans (SIPs) for Indiana, Illinois, Michigan, Wisconsin and Ohio. The Lake Michigan Air Directors Consortium (LADCO) supports the MRPO and supplied emissions, meteorological and chemistry files as well as photochemical model source codes used in this analysis. Indiana followed the U.S. EPA guidance in all modeling and attainment demonstration methods for this analysis.

Emissions Estimation Methodology

IDEM's Office of Air Quality adjusted the emissions in order to determine the impact of the discontinuation of the vehicle inspection and maintenance program in Clark and Floyd counties. LADCO provided the 2002 base case emissions and future year emissions for 2009 as well as the weighting factors to interpolate 2007 emissions between the 2002 and 2009 emissions. Future year 2009 emissions were created to account for economic growth and emission control strategies that will be in place by 2009 for all emissions sectors. Modeling results show the downward trend for each modeled year and validates this analysis.

LADCO provided a computer software patch to calculate 2007 emissions for all emissions sectors. The emissions adjustments for 2007 were an estimation of all emission sectors between the known (2002) and calculated (2009) future emission levels. The weighting factor consists of the fraction of the number of years from each time period. The weighting factors used for determining the 2007 emissions are 0.285 (2/7th of the emissions from 2002) for 2002 emissions and 0.714 (5/7th of the emissions from 2009) for 2009 emissions. The weighting factors were applied to the motor vehicle, low-level point, area sources (marine-air-rail, nonroad and other) and ammonia emissions. The weighting factors were not applied to the elevated point source

emissions because no significant emission changes are expected to that particular source sector between 2007 and 2009. Therefore, 2009 elevated point source emissions were used. Each emission sector file was quality assured to determine specific pollutant emissions in gram-moles/day, kilograms/day and tons/day. Once emission adjustments were made, all emissions sectors were merged to create 2007 emissions.

LADCO has a computer program that adjusts emissions for a specific county and emission sector. For the purpose of this analysis, the discontinuation of the vehicle inspection and maintenance program in Clark and Floyd counties only affected mobile emissions; therefore the mobile emissions were the only emission sector analyzed. The difference between the total 2007 emissions and the total 2007 emissions with Clark and Floyd counties emissions zeroed-out, represent the mobile emissions for Clark and Floyd counties. Table 1.1 shows the modeled mobile source emissions for Clark and Floyd counties for the years 2002, 2007 and 2009. All emissions data include the vehicle inspection and maintenance program in Clark and Floyd counties. The quality assured results of these emissions adjustments can be found in Appendix A. Also referenced in Appendix A are the total 2007 emissions, 2007 emissions minus the Clark County emissions and the 2007 emissions minus the Floyd County emissions.

Table 1.1
2002, 2007 and 2009 Mobile Source Emissions from Modeling Inventories

		2002 - summer		2007 - summer		2009 - summer	
		Clark	Floyd	Clark	Floyd	Clark	Floyd
		tons/day	tons/day	tons/day	tons/day	tons/day	tons/day
NOx	12km	13.74	5.43	10.4	3.95	8.43	3.37
	36km	20.96	5.38	15.45	3.88	13.26	3.28
VOC	12km	9.46	4.00	7.93	3.03	6.11	2.65
	36km	12.63	3.38	9.77	2.54	8.65	2.21
		2002 - winter		2007 - winter		2009 - winter	
		Clark	Floyd	Clark	Floyd	Clark	Floyd
		tons/day	tons/day	tons/day	tons/day	tons/day	tons/day
NOx	36km	23.6	6.09	17.39	4.39	14.93	3.72
VOC	36km	13.73	3.67	10.63	2.76	9.39	2.39

Based on the MOBILE6 emission modeling conducted to determine the impact on NOx and VOC emissions from the discontinuation of the vehicle inspection and maintenance program in Clark and Floyd counties, for the year 2007, the increase in NOx emissions was 0.78 tons per summer day and 0.82 tons of NOx per winter day. VOC emissions were calculated to increase by 0.79 tons per summer day and 1.49 tons per winter day. This change in the NOx and VOC emissions was then used to determine multipliers in order to adjust the mobile inventory in the modeling files. The multipliers were for both Clark and Floyd counties: NOx – 1.047 for summer and 1.048 for winter; VOC – 1.125 for summer and 1.134 for winter. The emission estimates were calculated for the six winter months of October, November, December, January, February and March and the six summer months of April, May, June, July, August and September. The emission adjustments were then made to the 2007 mobile modeling files with

Clark County NO_x and VOC emissions adjusted first and the Floyd County NO_x and VOC emissions adjusted second to account for the discontinuation of the vehicle inspection and maintenance program in those counties. This created the new 2007 mobile emission files which were quality assured and pre-processed with the other emission source categories for use in CAMx.

Photochemical Modeling Methodology

The Comprehensive Air Quality Model with extensions (CAMx) was the photochemical model used; this model is accepted by the U.S. EPA. The meteorology used was the summer of 2002 for ozone and the entire year of 2002 for PM_{2.5}. Three separate modeling runs were conducted; one model run to determine base year (2002) concentrations, one future year (2007) model run included additional NO_x and VOC emissions from the discontinuation of the vehicle inspection and maintenance program (without I/M), and one future year (2007) model run with the NO_x and VOC emission reductions associated with the vehicle inspection and maintenance program (with I/M). The 2007 ozone and PM_{2.5} modeled results were post-processed and evaluated using the U.S. EPA's attainment test guidelines. Future year design values were calculated from the modeling runs with and without the vehicle inspection and maintenance program being in place. The impact on the future year design values for ozone and PM_{2.5} monitors in Clark and Floyd counties was determined.

Photochemical Modeling Results for Ozone

The results of the 8-hour ozone attainment test compared the 2007 design values for Clark and Floyd counties with the vehicle inspection and maintenance program in place to the 2007 design values for Clark and Floyd counties assuming the discontinuation of the vehicle inspection and maintenance program. The difference in the future year design values were modeled at the Charlestown, Clark County and New Albany, Floyd County ozone monitors, as well as for the additional sites within the nonattainment area. The difference is an increase in the future year design value for ozone of +0.0001 ppm at the Charlestown ozone monitor. No difference in the future year design value for the New Albany site or other sites within the nonattainment area was determined. All design values are projected to be below the standard of 0.085 ppm. Table 1.2 lists the modeled results from the ozone attainment test and the difference in future year design values as a result of the discontinuation of the vehicle inspection and maintenance program for Clark and Floyd counties. Since only the third significant digit is used in computation and the modeled difference for the Charlestown site affects the fourth significant digit, there is virtually no difference in the modeled design values for any monitoring site. IDEM used the average of three design values (2000-2002, 2001-2003, and 2002-2004) for this assessment. The period of time associated with the average design value encompasses the design value that was used in designating the area nonattainment (2001-2003) and the design value used to support IDEM's redesignation petition for Clark and Floyd counties (2003-2005, with 2003 representing the base year).

Table 1.2
8-hour Ozone Attainment Results for Nonattainment Area

Monitor ID	ST	County	00_02	01_03	02_04	AVGDV	RRF	2007 FYDV	2007 No IM FYDV	Difference
			ppm	ppm	ppm	ppm		ppm	ppm	ppm
1801900031	IN	Clark	0.090	0.092	0.088	0.090	0.93	0.083	0.083	+0.0001
1804310041	IN	Floyd	0.083	0.086	0.084	0.084	0.93	0.078	0.078	0.0000
2102900061	KY	Bullitt	0.085	0.081	0.076	0.080	0.94	0.076	0.076	0.0000
2111100271	KY	Jefferson	0.085	0.079	0.075	0.085	0.94	0.075	0.075	0.0000
2111100511	KY	Jefferson	0.084	0.084	0.080	0.084	0.94	0.077	0.077	0.0000
2111110211	KY	Jefferson	0.083	0.079	0.076	0.083	0.94	0.074	0.074	0.0000
2118500041	KY	Oldham	0.087	0.086	0.083	0.085	0.93	0.079	0.079	0.0000

00_02 – design value from (2000-2002),

01_03 – design value from (2001-2003),

02_04 – design value from (2002-2004),

AVGDV – average of the 3 design values,

RRF – relative reduction factor – ratio of future year and base year modeling,

2007 FYDV – future year design value with Clark/Floyd I&M program, and

2007 No IM FYDV – future year design value without Clark/Floyd I&M program,

Difference – the part per million differences between the future year design values.

It should be noted that the ozone model performance is within the U.S. EPA guidance and is considered State Implementation Plan (SIP) quality. Information on the attainment test, calculating relative reduction factors and other additional 8-hour ozone documentation was taken from the “Guidance on the Use of Models and Other Analyses in Attainment Demonstrations for the 8-hour Ozone NAAQS.

Photochemical modeling was conducted by the U.S. EPA and LADCO in support of the Clean Air Interstate Rule (CAIR). The modeling results show future year design values for 8-hour ozone well within the 8-hour ozone NAAQS of 0.085 parts per million (ppm). Table 1.3 shows the U.S. EPA modeling results for CAIR. All sites in Clark and Floyd counties and in Bullitt, Jefferson and Oldham Counties in Kentucky are predicted to have future year design values in 2010 and 2015 below 0.085 ppm and will be in attainment.

Table 1.3
8-Hour Ozone Modeling Results from U.S. EPA for the Clean Air Interstate Rule

County	State	MSA/CMSA	Design Value 1999-2003	Future Design Value 2010 with CAIR	Future Design Value 2015 with CAIR
			(ppm)	(ppm)	(ppm)
Clark	Indiana	Louisville	0.0893	0.0784	0.0735
Floyd	Indiana	Louisville	0.0837	0.0752	0.0703
Bullitt	Kentucky	Louisville	0.0837	0.0731	0.0693
Jefferson	Kentucky	Louisville	0.0843	0.0749	0.0711
Oldham	Kentucky	Louisville	0.0880	0.0756	0.0710

Table 1.4 shows the LADCO – Round 4 modeling results for CAIR. All sites in Clark and Floyd counties and in Bullitt, Jefferson and Oldham Counties in Kentucky are predicted to have future year design values in 2009, 2012 and 2018 below 0.085 ppm and will be in attainment.

Table 1.4
LADCO's Round 4 8-Hour Ozone Modeling Results for the Clean Air Interstate Rule

Monitor ID	County	State	Design Value 2000-2004	2009 Future Design Value with CAIR	2012 Future Design Value with CAIR	2018 Future Design Value with CAIR
			(ppm)	(ppm)	(ppm)	(ppm)
180190003	Clark	Indiana	0.0900	0.0825	0.0792	0.0763
180431004	Floyd	Indiana	0.0843	0.0774	0.0757	0.0725
210290006	Bullitt	Kentucky	0.0807	0.0748	0.0720	0.0680
211110027	Jefferson	Kentucky	0.0797	0.0739	0.0709	0.0680
211110051	Jefferson	Kentucky	0.0827	0.0763	0.0744	0.0708
211111021	Jefferson	Kentucky	0.0793	0.0733	0.0717	0.0691
211850004	Oldham	Kentucky	0.0853	0.0776	0.0743	0.0715

Table 1.5 compares projected 2007 total emissions for Clark and Floyd counties with 2003 total emissions for Clark and Floyd counties. The 2007 and 2009 emission projections account for the discontinuation of the vehicle inspection and maintenance program. The base year for Indiana's request for Clark and Floyd counties to be redesignated to attainment under the 8-hour ozone standard is 2003. As Table 1.5 illustrates, the total emissions for 2007 and 2009 are projected to be less than 2003 emission levels, despite the mobile source VOC and NO_x emissions increasing by less than a ton each per summer day. The 2010 and 2020 emissions referenced in the maintenance plan remain below 2003 emissions as well, and have not been revised since the vehicle emissions testing program was excluded from the calculations. As illustrated in Table 1.6, once the 2007 emission reduction benefit for the vehicle emissions testing program is compared to the 2003 (base year) total emissions for the entire nonattainment area, the program yields well less than a 1% emission reduction benefit for VOC and NO_x. Historically, photochemical modeling sensitivity tests have shown that a local reduction of 15%-25% VOC is required to reduce ozone by 1 ppb.

Table 1.5
2003 and 2007 Emissions Comparison
Clark and Floyd counties (tons per summer day)

	2003	2007	2009
VOC	29.26	28.59	26.33
NO_x	51.77	41.89	38.82

Note: 2003 emissions include the vehicle inspection and maintenance program, 2007 emissions exclude the program.

Table 1.6

**Percentage Impact of I/M Emission Reduction on Base Year Emissions for
Entire Nonattainment Area (tons per summer day)**

	2003 Total	I/M Benefit	% Impact
VOC	133.11	0.79	0.6%
NOx	238.77	0.78	0.3%

Photochemical Modeling Results for Fine Particles

The attainment test for PM_{2.5} compared the 2007 design values for Clark and Floyd counties with the vehicle inspection and maintenance program in place to the 2007 design values for Clark and Floyd counties assuming the discontinuation of the vehicle inspection and maintenance program. This test was also conducted for the other sites within the nonattainment area. The difference in the future year design values was modeled at the Jeffersonville, Clark County and New Albany, Floyd County PM_{2.5} monitors as well as for the additional sites in Bullitt and Jefferson Counties in Kentucky. Table 1.7 lists the modeled results from the PM_{2.5} attainment test and the difference in future year design values as a result of the discontinuation of the vehicle inspection and maintenance program. The attainment test for PM_{2.5} offered speciation of the PM_{2.5} composition. This speciation includes sulfates, nitrates, organic and elemental carbon, ammonia and soil. The impact on the annual future year design value for PM_{2.5} was -0.1 ug/m³ at the Jeffersonville and New Albany PM_{2.5} monitors, as well as at several of the Kentucky sites. These results reflect an insignificant benefit resulting from the photochemical sensitivity associated with the affected species. The speciated modeling results of PM_{2.5} mass showed a minor impact for nitrates and ammonia from discontinuation of the vehicle inspection and maintenance program for Clark and Floyd counties. There are no 24-hour PM_{2.5} nonattainment areas in Indiana, so the 24-hour PM_{2.5} future year design values were not calculated.

Table 1.7

Annual PM_{2.5} Attainment Results for Clark and Floyd counties

Monitor ID	ST	County	Winter	Spring	Summer	Fall	2002 BYDV	2007 FYDV	2007 No IM FYDV	Difference
			ug/m3	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3	ug/m3
180190005	IN	Clark	15.9	16.7	20.5	15.5	17.2	15.7	15.6	-0.1
180431004	IN	Floyd	13.4	14.8	19.5	11.9	14.9	13.4	13.3	-0.1
210290006	KY	Bullitt	13.2	15	19.9	11.4	14.9	13.5	13.4	-0.1
211110043	KY	Jefferson	13.1	15.8	21.8	12.9	15.9	14.4	14.4	0.0
211110044	KY	Jefferson	14.2	16.1	22.5	13.5	16.6	15.1	15.0	-0.1
211110048	KY	Jefferson	13.3	15.5	22.2	13.2	16.1	14.6	14.5	-0.1

Winter – Winter quarterly modeled average for Base Year,

Spring – Spring quarterly modeled average for Base Year,

Summer – Summer quarterly modeled average for Base Year,

Fall – Fall quarterly modeled average for Base Year,

BYDV – Modeled Base Year Design Value,

2007 FYDV – future year design value with Clark/Floyd I&M program,

2007 No IM FYDV – future year design value without Clark/Floyd I&M program, and

Difference – the microgram per cubic meter differences between the future year design values.

It is worth noting that the PM_{2.5} model performance is outside the bounds for the bias, error, fractional bias and fractional error matrices, as per U.S. EPA photochemical modeling criteria. Improvement in the PM_{2.5} model performance is necessary. These modeling results may change with improved model performance, however, the impacts on the annual PM_{2.5} future year design values are expected to be minimal. The information on the attainment test and other additional PM_{2.5} documentation was taken from the “Guidance for Demonstrating Attainment of Air Quality Goals for PM_{2.5} and Regional Haze”.

Photochemical modeling was conducted by the U.S. EPA and LADCO in support of the Clean Air Interstate Rule (CAIR). The modeling results show future year design values for annual PM_{2.5} within the annual PM_{2.5} NAAQS of 15.0 micrograms per cubic meter (ug/m3). Table 1.8 shows the U.S. EPA modeling results for CAIR. Floyd County in Indiana and Bullitt County in Kentucky are projected to attain the annual PM_{2.5} NAAQS by 2010. All sites in Clark and Floyd counties and in Bullitt County in Kentucky are predicted to have future year design values in 2015 below 15.0 ug/m3 and will be in attainment. Jefferson County in Kentucky is predicted to exceed the annual PM_{2.5} NAAQS. However, it is within 3% of the standard in 2010 and 1% of the standard in 2015.

Table 1.8**Annual PM_{2.5} Modeling Results from U.S. EPA for the Clean Air Interstate Rule**

County	State	MSA/CMSA	Design Value 1999-2003	Future Design Value 2010 with CAIR	Future Design Value 2015 with CAIR
			(ug/m3)	(ug/m3)	(ug/m3)
Clark	Indiana	Louisville	16.90	15.15	14.79
Floyd	Indiana	Louisville	15.35	13.54	13.27
Bullitt	Kentucky	Louisville	15.61	13.67	13.13
Jefferson	Kentucky	Louisville	17.07	15.44	15.13

Table 1.9 shows the LADCO – Round 4 modeling results for CAIR. All sites in Clark and Floyd counties and in Bullitt, Jefferson and Oldham Counties in Kentucky are predicted to have future year design values in 2009, 2012 and 2018 below 15.0 ug/m3 and in attainment.

Table 1.9**LADCO's Round 4 Annual PM_{2.5} Modeling Results for the Clean Air Interstate Rule**

Monitor ID	County	State	Design Value 2000-2004	2009 Future Design Value with CAIR	2012 Future Design Value with CAIR	2018 Future Design Value with CAIR
			(ug/m3)	(ug/m3)	(ug/m3)	(ug/m3)
180190006	Clark	Indiana	16.5	14.5	14.0	13.7
180431004	Floyd	Indiana	14.9	13.2	12.8	12.3
210290006	Bullitt	Kentucky	15.0	13.3	12.8	12.2
211110043	Jefferson	Kentucky	16.8	14.2	13.8	13.3
211110044	Jefferson	Kentucky	16.5	14.8	14.4	13.7
211110048	Jefferson	Kentucky	16.0	14.3	13.9	13.9

Table 1.10 summarizes total NO_x emissions for Clark and Floyd counties for the years 2002 (base year for the PM_{2.5} standard with I/M in place), 2007 (assuming the discontinuation of the I/M program), and 2009 (the deadline for monitoring attainment of the standard). As Table 1.10 illustrates, total NO_x emissions for the years 2007 and 2009, with the reductions associated with the vehicle emissions testing program excluded, are less than the total NO_x emissions in 2002 (the base year for the standard) when the program was in place.

Table 1.10

**NO_x Emissions Analysis for PM_{2.5}
Clark and Floyd counties (tons per day)**

	2002	2007	2009
NO_x	57.59	41.89	38.82

Conclusions

IDEM's Office of Air Quality conducted an ozone and PM_{2.5} assessment to determine if there would be impacts from additional mobile source VOC and NOx emissions as a result of the discontinuation of the vehicle inspection and maintenance program for Clark and Floyd counties. Photochemical modeling was conducted for the summer of 2002 for ozone and the entire year of 2002 for PM_{2.5}. CAMx is the U.S. EPA accepted photochemical model used in conjunction with emissions and chemistry files obtained from the MRPO. Emission adjustments were made to the 2002/2009 emission files in order to create a 2007 emissions profile. The motor vehicle emissions for Clark and Floyd counties were determined and the anticipated increase in NOx and VOC emissions were added to the 2007 emissions inventory.

Modeling results were used in the U.S. EPA attainment tests for 8-hour ozone and annual PM_{2.5} to determine if additional VOC and NOx emissions associated with the discontinuation of the vehicle inspection and maintenance program would impact the ozone and PM_{2.5} monitors in the nonattainment area. Based on the attainment tests, there was an increase of +0.0001 ppm for the future year ozone design value at the Charlestown ozone monitor. Since only the third significant digit is used in computation and the modeled difference for the Charlestown site affects the fourth significant digit (.0001), there is virtually no difference in the modeled design values for either site in Clark and Floyd counties. The projected design value for 2007(.084 ppm) is below the 8-hour ozone standard and identical to the design value that serves as the base year in the redesignation petition and maintenance plan (2003-2005, with 2003 serving as the base year). More importantly, once the discontinuation of the vehicle inspection and maintenance program is accounted for, 2007 VOC and NOx emissions are projected to be lower than 2003 NOx and VOC emission levels. Therefore, the discontinuation of the vehicle inspection and maintenance program for Clark and Floyd counties will not interfere with attainment of the 8-hour ozone standard (or any other applicable requirement of the Clean Air Act).

A difference of -0.1 ug/m³ of the annual future year design values for several monitors within the nonattainment area was found, with the difference coming from nitrate concentrations. Though this reflects a potential benefit, a one-tenth of a microgram per cubic meter impact is negligible. More importantly, an emissions analysis demonstrates that total NOx emissions for the years 2007 and 2009, with the reductions associated with the vehicle emissions testing program excluded, are less than the total NOx emissions in 2002 (the base year for the standard) when the program was in place. Therefore, the discontinuation of the vehicle inspection and maintenance program for Clark and Floyd counties will not interfere with the area's ability to achieve reasonable progress towards attainment of standard by its assigned deadline (April 5, 2010).